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(54) **Plug valve assembly**

(57) A plug valve assembly (10) comprises a casing or housing (11) having a valve member (19) therein which is retained in a closed position by virtue of a sleeve (18) retained in a closed position by a retaining means in the form of locking collets (21), the retaining means being held captive in the housing (11) by a cylinder (12) which forms part of the valve assembly, and which is coupled with an operating rod (15), the operating rod engaging the cylinder (12) via a first set of spring loaded balls (13, 14) and engaging the sleeve (18) via a second set of spring loaded balls (16, 17), whereby repeated short movements of the actuator rod (15) can be triggered by pressure pulse applications, to cause the cylinder (12) to move in the same manner as an incremental linear actuator mechanism. The cylinder therefore is moved progressively upwardly out of engagement with the retaining means (locking collets), which can then fall away and release the sleeve (18) to move downward and thereby allow the valve to open.

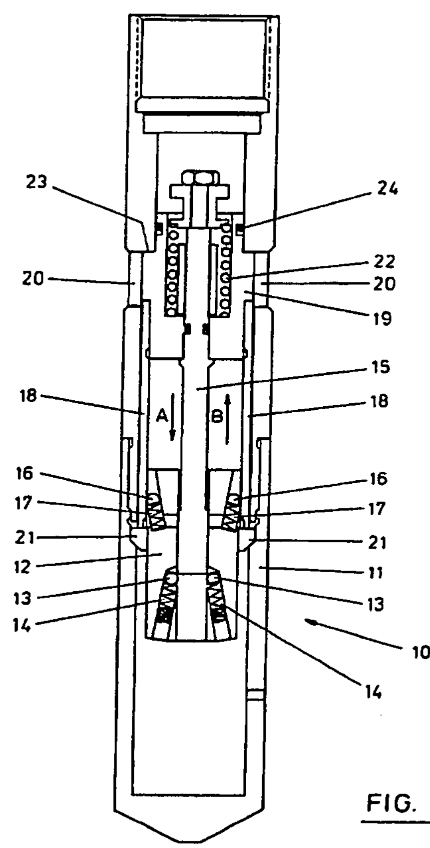

FIG. 1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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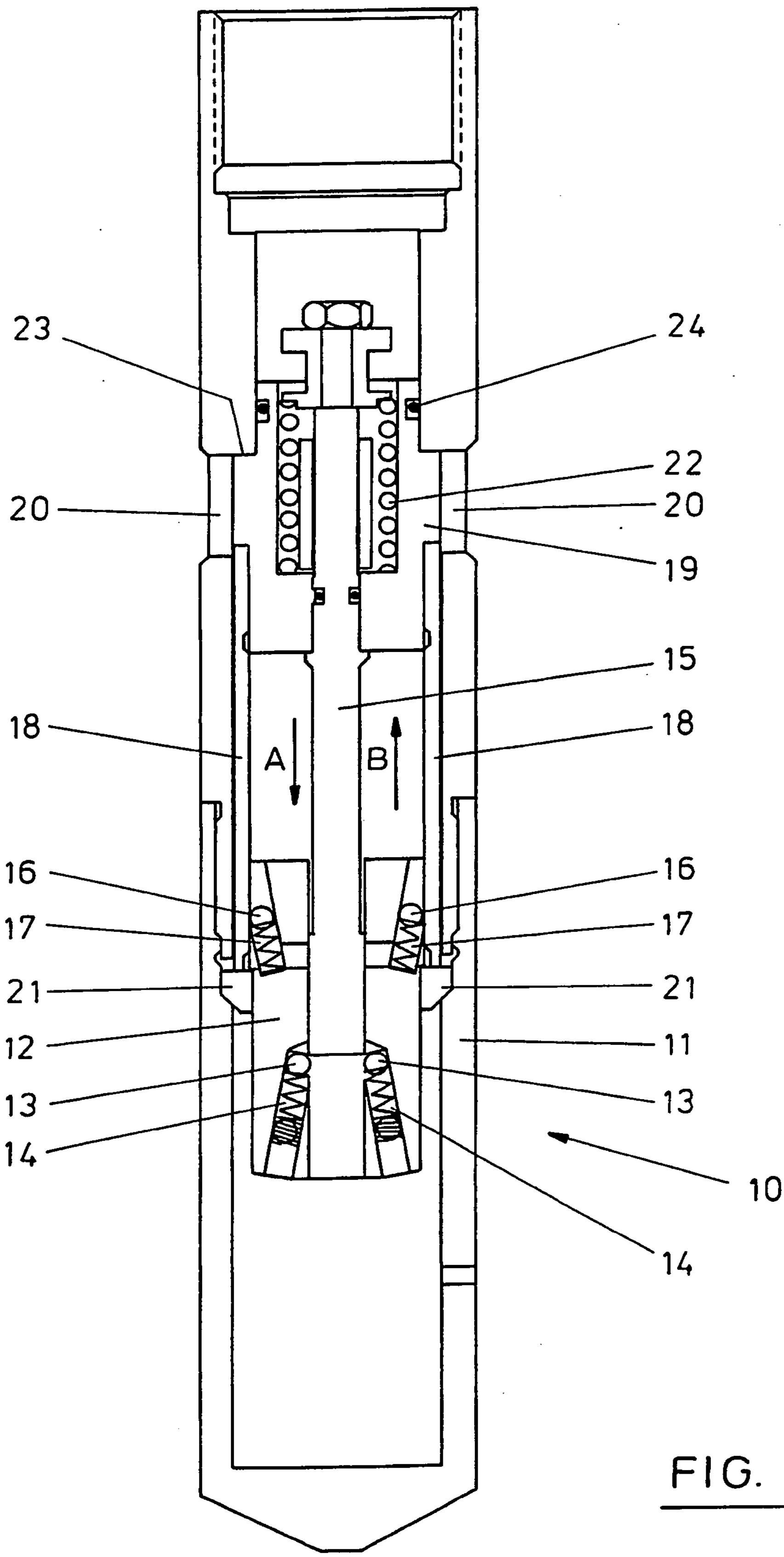


FIG. 1

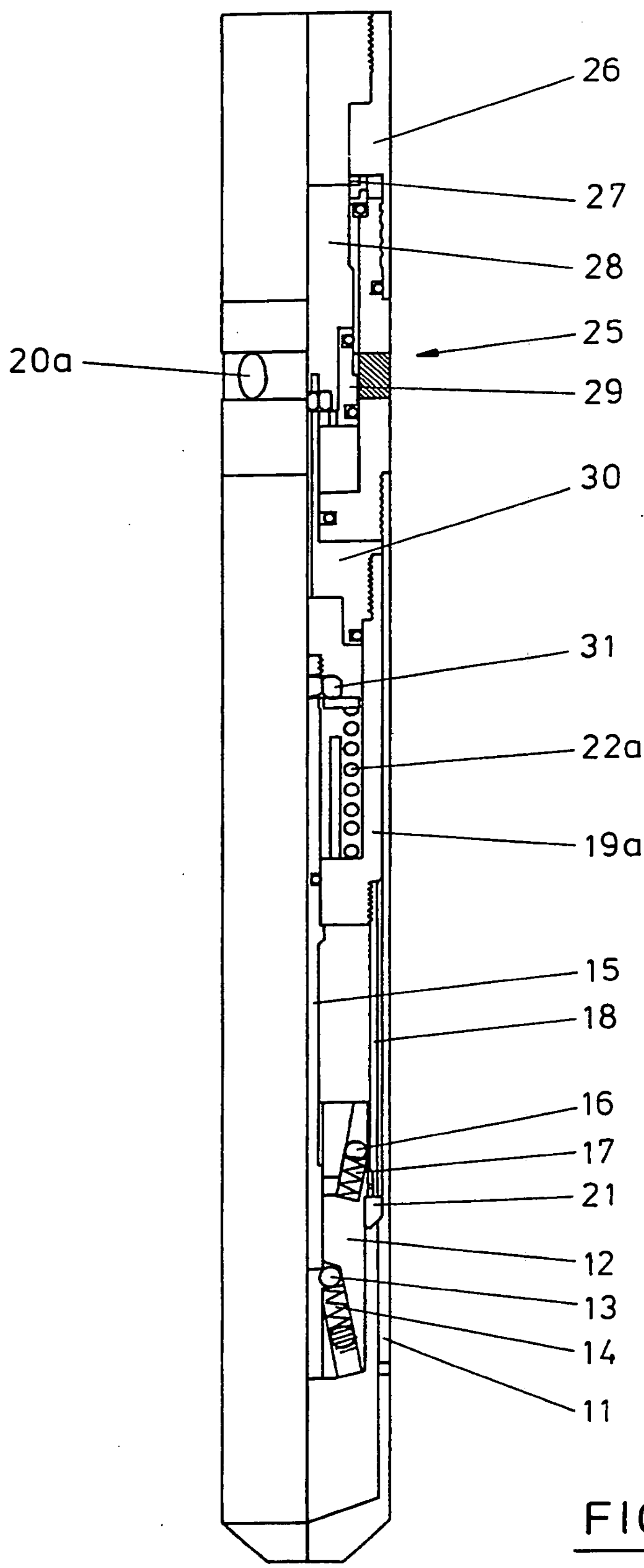
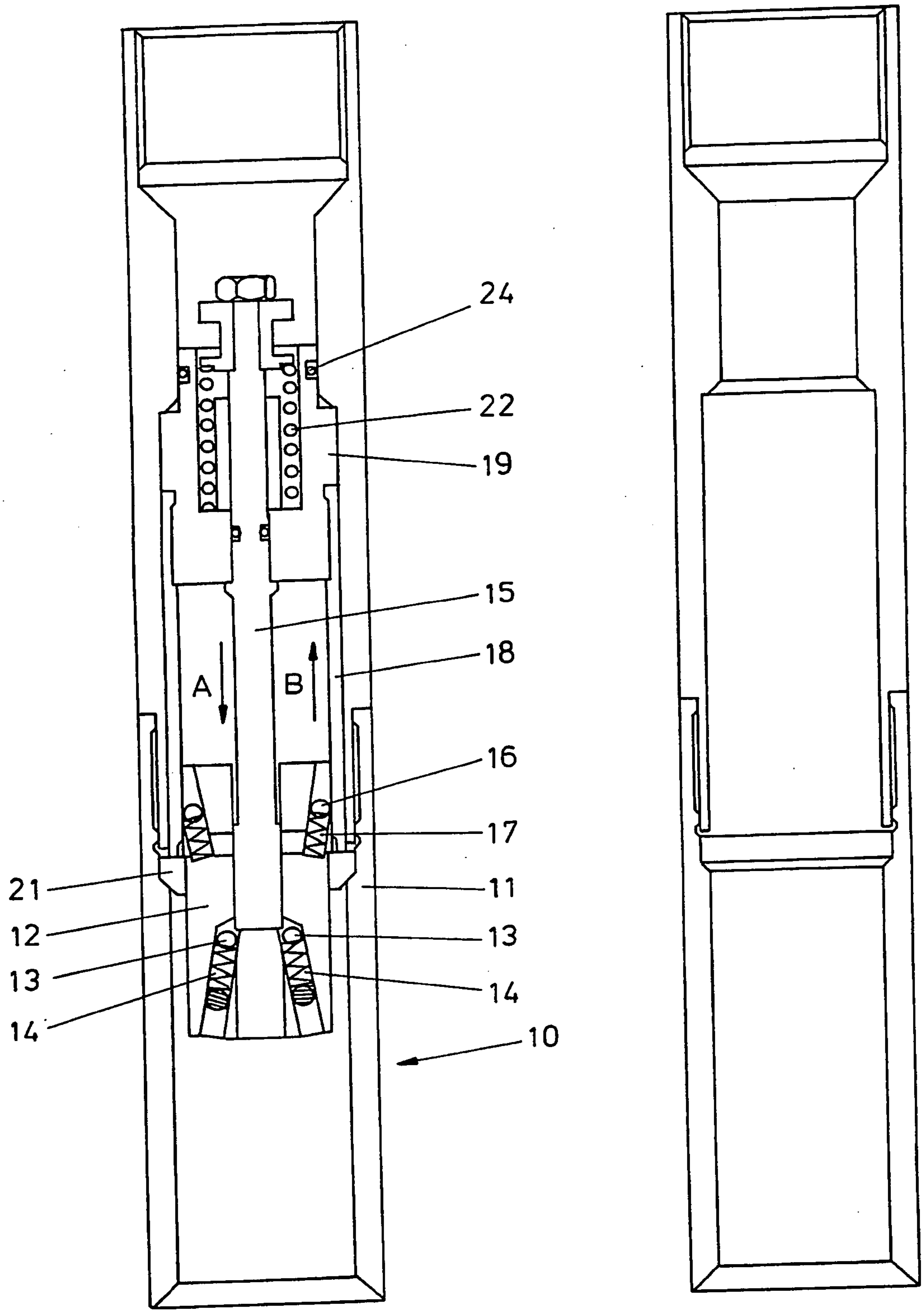


FIG. 2



(a) (b)

FIG. 3

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PLUG VALVE ASSEMBLY

This invention relates to a plug valve assembly especially, though not exclusively, for use in oil, gas and water wells.

In the oil and gas recovery industry there are many operations which may be carried out on a well during its lifetime. All oil or gas wells have equipment associated therein which require regular maintenance. To carry out this maintenance "plugs" have to be installed at various depths in the well by wireline operations to make the well safe.

Oil, gas and water wells are all equipped with "nipples" which are special profiles designed to house flow control and safety devices. A "lock mandrel" may be installed into one of these nipples with an additional device attached to the bottom to perform a desired function. A complete family of devices exist to close off flow and pressure from the well called plugs, pump open plugs, pressure cycle plugs, safety valves, and shut in tools. These devices have many different methods of operation i.e. mechanical, hydraulic or electrical.

All plugs have to be designed to hold pressure differentials in both directions. Pressure from below is built-up due to well build-up pressure, and pressure from above due to the fact that equipment above the plug will be pressure tested by pressurising against the plug.

According to the invention there is provided a plug valve assembly comprising a housing having a valve member therein, said valve member being retained in a closed position by virtue of a sleeve retained by a retaining means engageable with a cylinder provided with an operating rod, the operating rod engaging the cylinder and the cylinder engaging the sleeve by virtue of spring loaded angled ball assemblies, and the arrangement being such that the operating rod may move through the cylinder in one direction, but moves the cylinder when it returns in the opposite direction whereby successive movements of the operating rod move the cylinder out of engagement with the retaining means such that the retaining means release the

sleeve allowing the valve to open.

The retaining means may comprise a ball race, or one or more locking collets, or any other suitable device.

In a normal oil well there is a positive pressure at the wellhead. Opening a valve at the wellhead will cause a pressure drop which in turn will cause the well to flow. When such a well is plugged using a plug valve assembly of the type herein described, the pressure after setting will be balanced above and below. If however the pressure is bled off at the surface, an imbalance will be produced across the plug having a negative differential. The pressure below the plug will be greater than the pressure above. This will aid the operation of the plug as not only will the spring loaded assemblies act on the central operating rod, but the well pressure will also assist.

Preferably, a top sub-assembly is coupled (directly or indirectly) with the operating rod via a probe sub and may have a sleeve which is wider at the top than at the bottom, so that an area imbalance is present which creates an upward force of slightly less than the downward force from the probe sub. This allows the plug to function in conditions of over balance.

In one embodiment, the tool may have a nose section or housing design into which the component parts of the core can be caught, upon opening of the tool.

However, in a further embodiment, which is preferred for certain uses, no provision is made to catch the component parts of the core, upon opening of the tool i.e. the nose section or housing cannot retain these components. This allows the core components to fall away into the sump of the wellbore, which thereby allows full bore access to the producing formation after opening.

Embodiments of the present invention will now be described in detail, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a longitudinal sectional view of a first embodiment of a plug valve assembly according to the invention;

Figure 2 is a partial sectional view of a second

embodiment of plug valve assembly according to the invention; and,

Figure 3 is a longitudinal sectional view of a modification of the embodiment shown in Figure 1, and having different mode of use, with Figures 3a and 3b showing the positions taken up by the component parts, respectively, before operation and after operation.

Referring first to Figure 1 of the drawings, there will be described a so-called "cycle plug" which is a type of plug valve assembly which can be used to close-off flow and pressure from an underground reservoir containing fluid under pressure, such as liquid and / or gaseous hydrocarbons, and water wells. A valve assembly of this type must be designed to hold pressure differentials in both directions, namely pressure from below which is built-up due to well build-up pressure, and pressure from above due to the fact that equipment above the assembly will be pressure tested by pressurising against the plug.

Furthermore, a cycle plug is usually arranged to be capable of being remotely released by controlled application of a predetermined number of pressure pulses in the space above the plug.

Alternatively, or in addition, cycle plugs can be arranged to be remotely triggered to a release position by repeated mechanical jarring forces applied to the upper side of the plug.

The cycle plug which will now be described with reference to Figure 1 of the drawings is of a type which can be remotely triggered by repeated application of fluid pressure impulses, or mechanical jarring forces, according to the wishes of the user.

Accordingly, in general terms, the cycle plug shown in Figure 1 is a "slickline" device for use with a standard lock mandrel, and in which the tool will release i.e. be opened to allow fluid flow from the well to resume, after it has been exposed to a pre-set number of pressure cycles from above, or by mechanical triggering.

One main application of the cycle plug is to allow

production to resume from a well, following pressure testing, and without immediate wireline intervention and retrieval of plugs which may have a sand or fill build-up. Once the cycle plug has opened, any debris may be pumped or flow away.

The cycle plug tool is screwed to the bottom of an equalising assembly during operation, and can operate on differential pressure from above, typically at a minimum of 1000 psi. Each cycle is performed on the bleed-off phase. Although normally set for ten cycles to trigger opening, this required number of cycles may be reduced. Mechanical operation may be achieved by gentle jarring ten times with a prong.

The plug valve assembly shown in Figure 1 will now be described in detail, and is designated generally by reference 10, comprising an outer cylindrical housing 11 in which is mounted the operating mechanism of a plug valve type assembly, which comprises a solid cylinder 12 having two different sets of oblique passages drilled therein, and each accommodating a respective spring-loaded locking ball. A lower set comprises balls 13 pressed by springs 14 in a direction which is part upwardly and part radially inwardly to engage the peripheral outer surface of an actuator rod 15, and an upper set comprises balls 16 pressed by springs 17 in an upward and also radially outward direction to engage the cylindrical inner surface of a sleeve 18.

The actuator rod 15 passes through a central passage formed in the cylinder 12, and the engagement of the balls 13 with the rod 15 is such as to allow downward movement of the rod 15 in the direction of arrow A, upon application of hydraulic pressure to the upper end of the assembly, but relative upward movement of the rod 15 being prevented by gripping action of the balls 13 against the outer periphery of the rod 15.

Somewhat similarly, sleeve 18, which is fitted over the cylinder 12, can only move in the direction of the arrow B by reason of the engagement of the balls 16 with the internal surface of sleeve 18.

Accordingly, repeated short movements of the rod 15 can

cause the cylinder 12 to move in the same manner as an incremental linear actuator mechanism.

The upper part of the "tool" incorporating the plug valve assembly includes a valve core 19 which is secured to the upper end of sleeve 18, and which can move with the sleeve 18, although is shown occupying a position in which flow ports 20 formed in the wall of the housing 11 are blocked by the valve core 19. The valve core 19 is retained in the position shown in Figure 1, when the plug assembly is in a closed position, by means of a set of locking collets 21 (or locking balls) mounted in the wall of the housing 11, and engaging the lower end of sleeve 18.

The actuator rod 15 of the valve assembly can be stroked hydraulically in the direction of arrow A, and returned by a mechanical spring 22 housed in the upper part of the tool, and when the cylinder 12 (which is coupled to move with the rod 15 via the balls 13) has moved upward by repeated hydraulic pressure cycles applied above the valve assembly and has passed the locking collets 21, this allows the latter to drop into the bottom of the tool (the cylinder 12 in the position shown in Figure 1 holds the collets 21 in the locking position against a seating provided for it in the wall of the housing). The valve core 19 can then move downwardly away from a valve seat 23, and thus allow pressure or flow to transmit through the tool via the ports 20.

An upper sealing ring in the form of an O-ring 24 seals the sliding movement of the valve core 19.

The pressure cycle plug or valve assembly described above is able to operate satisfactorily and reliably to close off flow and pressure from an underground reservoir, in most operating conditions. Therefore, this embodiment, in general terms is just one example of a plug valve assembly which comprises a casing or housing having a valve member therein, in which the valve member is retained in a closed position by virtue of a sleeve (18) retained in a closed position by a retaining means (locking collets 21), and in which the retaining means is held captive in the housing (11) by a

cylinder (12) which forms part of the valve assembly, and which is coupled with an operating rod (15), and in which the operating rod engages the cylinder (12) via a first set of spring loaded balls 13, 14 and engages the sleeve (18) via a second set of spring loaded balls (16, 17).

The arrangement is such that the operating rod (15) can move through the cylinder 12 in one direction, but moves the cylinder when it returns in the opposite direction, whereby successive movements of the operating rod move the cylinder (12) upwardly out of engagement with the retaining means (locking collets 21) which can then fall away and release the sleeve 18 to move downward and thereby allow the valve to open.

The embodiment shown in Figure 1 operates generally satisfactorily and reliably in most operating conditions, but cannot be guaranteed always to operate reliably when certain conditions of differential pressure exist above the tool when it is set. This problem with differential pressure also applies to other types of plug valve assemblies currently available.

Thus, in a normal oilwell, there is a positive pressure at the wellhead. Opening a valve at the wellhead will cause a pressure drop and the well to flow. When this type of well is plugged with a cycle plug or other device, the pressure after setting will be balanced both above and below. If the pressure is bled-off at the surface, an imbalance will be noticed across the plug, which is a negative differential i.e. the pressure below will be greater than the pressure above. This will aid the operation of a cycle plug, as the usual spring mechanism available will act on the central operating rod, but in addition the well pressure will assist the action of the spring mechanism.

However, if a cycle plug is set in the same well and an oil / gas mixture above the plug is replaced by water or a "kill" fluid for safety or operational reasons, a positive pressure differential would now exist across the plug i.e. a greater pressure above than below. The cycle plug would then have great difficulty in operating, as not only is this

increased pressure partially compressing the operating spring and reducing its operating length, but a whole new set of forces act on the mechanism tending to cause it to "lock-up".

It is a purpose of a second preferred embodiment of the invention, which will now be described below with reference to Figure 2, to improve the operating performance of the first embodiment described with reference to Figure 1.

Parts corresponding with those already described with reference to the first embodiment are given the same reference numerals, and will not be described in detail again.

The bottom half of the "tool" shown in Figure 2 is generally similar to the tool of Figure 1, except that the spring 22 of Figure 1 is increased in strength, and is designated by reference 22a in Figure 2. Furthermore, the internal diameter of the tool of Figure 1 i.e. the diameter at seal 24, is reduced in order to reduce the surface area exposed to pressure (in the tool of Figure 1, with a diameter of 1.5 inches at seal 24, and 1,000 psi pressure above, and zero below, this will generate a net downward force of 1767 lbs).

Also, in the tool shown in Figure 2, the valve core 19 of Figure 1 is altered in design, and is designated by reference 19a, and this component, in combination with a sleeve 29 of a top sub assembly 25 form together the valve core which is capable of moving downwardly, upon release of the locking collets 21, in order to allow flow through the tool to resume via ports 20a in the wall of the top sub assembly 25.

The additional "top sub" applied to the tool Figure 2 is designated generally by reference 25, and includes X-over 26, diaphragm 27, balance sleeve 28; and the top sub 25 is screwed to the top of the overall housing or casing 11 of the bottom part of the tool.

The top sub assembly 25 also includes a probe 30 which is screwed to the top of component 19a of the bottom part of the tool. Nut 31 fits on the threaded top end of actuator rod 15 to hold the bottom sub assembly together.

The probe 30 of the top sub assembly 25 has a central drilling in order that the pressure above it can communicate

with a sealed chamber defined below it which houses spring 22a.

The sleeve 29 is designed such that an area imbalance is present, creating an upward force slightly less than the downwards force from the probe 30. Therefore, when the tool has fully cycled, by application of repeated pressure impulses to the fluid column above the plug valve assembly, and the locking collets 21 have dropped into the bottom of the tool, the differential pressure above acting on the small area of imbalance causes the entire core (sleeve 30 and component 19a) to drop, pulling the sleeve 30 downwards, which opens the flow ports and allows full communication above and below the tool.

The improved embodiment is therefore better able to function, and to allow flow to resume, in conditions of pressure overbalance.

Referring now to Figures 3a and 3b of the drawings, this shows an improvement in or modification of the embodiment shown in Figure 1, and illustrates a different mode of use. Parts corresponding with the embodiment shown in Figure 1 are designated by the same reference numerals, and will not be described in detail again.

The mechanism disclosed in Figure 3 is generally similar to the mechanism disclosed in Figure 1, but the operation is different when the tool opens. Thus, in the embodiment of Figure 1, the component parts of the tool are retained by a nose section or housing after opening. However, in the embodiment of Figure 3, these components are allowed to fall away into the sump of the wellbore. By so doing, this allows full bore access to the producing formation after opening.

The "pump away cycle plug" disclosed in Figure 3 is therefore intended to constitute a disposable means of plugging a wellbore whilst running a new completion, but which is capable of allowing a number of pressure tests to be carried out before disposal.

The mechanism disclosed in Figure 3 therefore replaces what would normally be termed the "tail pipe", "wireline re-entry guide" or "mule shoe". Screwed directly above the mechanism will be the usual production tubing and accessories.

The mechanism is conveyed to the bottom of the wellbore on pipe or tubing. After all of the pipe or tubing has been run, but prior to start-up of production from the well, the tubing and accessories must be pressure tested. Following successful pressure testing, additional pressure cycles from above will function the tool, allowing the "core" of the tool to be disposed of (since it is no longer caught by the nose section or housing after opening as with the embodiment of Figure 1), and then the well is able to flow.

The remaining "outer housing" portion, left after tool opening, now acts as the re-entry guide or mule shoe.

The advantages of the modified device of Figure 3, and the different mode of operation, are as follows:

Normally, any plugging device must be retrieved by a wireline, prior to producing from a well. This is time consuming and can be liable to operational problems.

Also, in highly deviated or horizontal wells, wireline retrieval can be impossible, because gravity force is required to convey the wireline and the tools to the part of the wellbore where the work is being done.

In addition, by use of the "pump away cycle plug" of Figure 3, wells may be completed, and then suspended. At a later date, the plugged well can be "brought on stream" without downhole intervention i.e. wells with subsea completions where no access to the well exists, by use of the tool of Figure 3.

CLAIMS

1. A plug valve assembly comprising a housing having a valve member therein, said valve member being retained in a closed position by virtue of a sleeve retained by a retaining means engageable with a cylinder provided with an operating rod, the operating rod engaging the cylinder and the cylinder engaging the sleeve by virtue of spring loaded angled ball assemblies, and the arrangement being such that the operating rod may move through the cylinder in one direction, but moves the cylinder when it returns in the opposite direction whereby successive movements of the operating rod move the cylinder out of engagement with the retaining means such that the retaining means release the sleeve allowing the valve to open.

2. A valve assembly according to Claim 1, in which the retaining means comprises a ball race.

3. A valve assembly according to Claim 1, in which the retaining means comprises one or more locking collets.

4. A valve assembly according to any one of Claims 1 to 3, including a top sub-assembly coupled with said operating rod via a probe sub having a sleeve which is wider at the top than at the bottom, so that an area imbalance is present to create an upward force of slightly less than the downward force from the probe sub.

5. A valve assembly according to any one of Claims 1 to 4, in which the tool has a nose section or housing design such that the component parts of the core can be caught, upon opening of the tool.

6. A valve assembly according to any one of Claims 1 to 4, in which the nose section or housing are designed to allow the core components to fall away, upon opening of the tool, thereby to allow full bore access to a producing formation after opening of the tool.

7. A valve assembly according to Claim 1 and substantially as hereinbefore described with reference to, and as shown in any of the embodiments illustrated in the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report)

Application number
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Relevant Technical Fields

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(ii) Int Cl (Ed.5) E21B 33/12

Search Examiner
MR D J HARRISON

Date of completion of Search
6 DECEMBER 1994

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii)

Documents considered relevant following a search in respect of Claims :-
1 TO 7

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
A	US 4469173 A (GILBERT ET AL)	1
A	US 4405017 A (ALLEN ET AL)	1
A	US 4188999 A (AMANCHARLA)	1

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